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November 25, 1992

Ms. Donna R. Searcy
Secretary
Federal Communications Commission
1919 M Street, N.W., Room 222
Washington, D.C. 20554

Dear Ms. Searcy:

Transmitted herewith on behalf of Cornell University is an original and four copies of a Petition for Rulemaking which seeks to establish a radio astronomy communications zone to protect radio astronomy operations at the Arecibo Observatory near Arecibo, Puerto Rico.

An extra copy of the first page of the petition is enclosed. Please date stamp that page as having been received and return it to the undersigned in the enclosed self-addressed, stamped, envelope.

Should there be any questions concerning this matter, kindly communicate with the undersigned.

Respectfully submitted,

Christopher J. Reynolds

BEFORE THE

Federal Communications Commission

WASHINGTON, D.C. 20554

In the Matter of	)
	)
Amendment of Parts 5, 21, 22, 23, 25, 73, 74, 78, 80, 87, 90, 94, 95 and 97 of the Rules to Establish a Radio Astronomy Communications Zone in Puerto Rico	)

To: The Chief, Policy and Rules Division

PETITION FOR RULEMAKING

Cornell University ("Cornell"), by its attorney, hereby requests the Commission pursuant to Section 1.401 of the Commission's Rules, to amend its rules to require that all applicants for new facilities and for modifications of existing authorizations in communications services governed by the above-captioned Rule Parts provide written notification to the Arecibo Observatory operated by Cornell near Arecibo, Puerto Rico, in order to permit Arecibo Observatory to determine whether applications might cause harmful interference to the radio astronomy facilities there and if so, to permit Arecibo Observatory to file objections with the Commission. In support whereof, the following is shown:

Preliminary Statement

The Arecibo Observatory is operated by Cornell under a cooperative agreement with the National Science Foundation ("NSF") and is part of the National Astronomy and Ionosphere Center. The Observatory houses the world's largest radio/radar telescope which has a reflector 1000 feet in diameter, a depth of 167 feet and a primary surface collection area covering 20 acres. The Arecibo Observatory is located approximately 17 kilometers south of Arecibo, about 30 miles east and 15 miles south of the northeast corner of Puerto Rico, in island some 100 miles from east to west and 40 miles north to south. The longest distance from the Arecibo Observatory over land to the sea is only 70 miles. A central mountain range from east to west along the island shields the southeastern region of Puerto Rico from the Observatory, but despite the rugged terrain, the Observatory has

direct or nearly-direct line-of-sight to 70 percent of the island territory and to the communications transmission facilities authorized to operate there.

The Observatory plays a leading international role as a versatile research instrument in radio physics, employing sensitive receivers, powerful planetary and ionospheric radar transmitters and sophisticated data acquisition and analysis equipment. Basic research is being conducted there in radio astronomy, radar astronomy and atmospheric science. The telescope operates 24 hours a day, each day of the year, and yet demand for its use by scientists is so heavy that there is a backlog of approved research proposals of nearly one year. The Observatory's telescope has been used to obtain detailed radar maps of Venus, precise pulsar measurements demonstrating the existence of gravitational radiation and of planets, and observations of hydrogen and molecules in galaxies far beyond the Milky Way.

The Observatory was originally designed to operate at frequencies up to 500 MHz but recently it has been used at 12 GHz. At a cost of $22.8 million provided by NSF and the National Aeronautics and Space Administration ("NASA"), the telescope is presently being upgraded so that it will be able to make routine observations anywhere between 50 MHz and 12 GHz. For the first time, systematic searches for neutral hydrogen and molecules at frequencies below 1000 MHz which signal events in the very early universe can be conducted at Arecibo. In combination with reduced system temperatures, the sensitivity of the world's most sensitive telescope will be increased by 50 percent. As a result, observation times will be reduced by a factor of more than 10 but Arecibo will be even more susceptible to radio frequency interference.

The Need for Protection Against RF Interference

Given its relatively small size, Puerto Rico is one of the most congested communications areas in the United States. The 1992 edition of Broadcasting & Cable Market Place (R.R. Bowker, pub.) lists 117 radio stations, 34 full-service television stations and 8 LPTV stations in operation or authorized to operate in Puerto Rico. In addition, there are uncounted numbers of broadcast auxiliary and experimental stations, satellite earth stations, domestic public and private fixed and mobile radio stations, aviation stations and amateur stations to name a few. Because of the rugged local terrain, many stations locate their transmitters on higher elevations in order to provide usable island service. The Arecibo Observatory enjoys very little natural shielding for radiation sources over a large fraction of the island because its observatory platform, located on high terrain,

is further significantly elevated and is thus vulnerable to signals coming across the horizon. External RF radiation has dramatically increased over the past decade and there appears to be no possibility of abatement in the future.

Analogous with the need to protect optical observatories from light pollution problems, radio astronomy telescopes must be protected from ambient radio noise. Cosmic signals they study are extremely weak; all the radio power collected by all the radio telescopes on earth since radio waves from space were discovered in 1932 would not suffice to light a single light bulb. The great sensitivity of large radio telescopes like those at Arecibo and Green Bank have given scientists the opportunity to observe radio waves emitted from objects in our universe. For example, radio astronomers have been able to study hydrogen gas within the Milky Way and to map its density and motions, showing the spiral nature of our Galaxy which is invisible optically. Radio astronomy has facilitated the discovery of bright radio sources, some almost invisible with optical telescopes, which may be the remnants of supernova explosions. Radio sources include the sun, the moon, most planets, stars, galaxies, quasars, gases such as hydrogen, atoms such as carbon and molecules such as carbon monoxide, water and formaldehyde.

The detection of weak signals is important in radio astronomy because the most distant and oldest objects in the universe will usually produce the weakest signals on earth. As the distance from earth is doubled, the signal received diminishes to one-fourth of its previous value. The signals from distant objects travel farther to reach the earth and therefore date back further in time. For example, the sun's rays leave the sun eight minutes before they reach the earth; radio signals from quasars ten billion light years distant (one light year is equal to six trillion miles) began their journey ten billion years ago. One of the central achievements of 20th century astronomy is the recognition that the universe is expanding. This led to the formulation of what is known as Hubble's Law, that the velocity of separation between two galaxies is proportional to their distance from one another. The radio emissions of remote objects are always red-shifted, that is, the radio frequency of neutral hydrogen, for example, which radiates at 1420.4058 MHz, is shifted to lower frequencies as the emitting source moves away from Earth. Hydrogen signals from other galaxies have been studied over the whole range of 450 to 1420 MHz.

To study cosmic signals, radio astronomers must use sophisticated, state-of-the-art electronic equipment and the prevention of interfering noise is of paramount importance. The performance of a radio astronomy telescope can be improved by increasing the

receiving surface used and minimizing the system temperature. Arecibo Observatory will achieve both aspects with the current upgrade program. This improvement in sensitivity, however, results in weaker interfering signals becoming more noticeable. Man-made signals that previously had been masked behind the noise generated within the telescope's electronics have become more prominent. The benefits of greater sensitivity are further degraded by increases in the general level of electromagnetic activity worldwide.

To partially offset this degradation, the Commonwealth of Puerto Rico has established a Protection Zone with a radius of four miles surrounding the Arecibo Observatory. This Protection Zone effectively helps the Observatory to control RF interference generated in the immediate vicinity by faulty household appliances, electric fences or welding equipment. In addition, the Puerto Rico Planning Board has drafted new zoning regulations which will prohibit microwave links from running through or being directed at the eight-mile diameter of the Protection Zone. Microwave links operating in the vicinity of the Observatory will henceforth be required to coordinate with the Observatory to reduce if not eliminate RF interference. Nevertheless, these regulations must be made more visible; no other protection against RF interference is accorded to Arecibo Observatory.

As stated above, the RF interference at Arecibo Observatory has drastically worsened during the last ten years. Ten years ago a radio astronomer could make a secure detection of a signal during one observation. Presently, an observer must check any detection with a second or third observation in order to verify the results. The spurious interfering signals increase the time necessary to conduct research and result in wasted observing time. With the demand for using the Arecibo telescope backlogged for nearly a year, the increased RF interference compounds these problems. Attachment B hereto is a statement of Dr. Ing. Willem Baan, Senior Research Associate and Frequency Manager at Arecibo Observatory, which describes the severity of the interference. According to Dr. Baan there is a high level of radiation generated by terrestrial communications sources within the frequencies of 1300 to 1430 MHz containing the 1400 - 1427 MHz band in which radio astronomy has primary status. The vulnerability of the Arecibo Observatory to congestion in this protected band is further exemplified by recent instances of potentially harmful radiation from two nearby broadcast stations, WNIK-FM, Arecibo, and WCCV-TV, Camuy. Although, in the case of WNIK-FM, the potential interference (from an applicant competing for WNIK-FM's license) was avoided by virtue of the FCC's decision

to renew WNIK-FM's license, in the case of WCCV-TV, a construction permit modifying the television station's facilities was awarded by the Commission before the Observatory became aware of the new construction. The FCC staff has been apprised of the problem and attempts are underway to informally resolve the interference, but no definitive resolution has yet been achieved.

The Observatory is actively involved in steps to suppress or eradicate the access of interfering signals to the receiving systems. The design of the telescope provides a significant advantage. The extemely high forward gain of the main beam is directed upwards, never reaching an angle of more than 20 degrees from the vertical. Hence, interfering radiation from the horizon enters only through the far sidelobes, which are typically one million to one hundred million times less sensitive than the main beam.

A major feature of the present upgrading program is to reduce this sidelobe level still further. Direct line of sight access to the receiving feeds will be eliminated at frequencies above 300 MHz by enclosing the new feed system and its subreflectors in a 83-foot diameter shielded enclosure. The enclosure entrance "pupil" accepts cosmic radiation reflected upward from the primary mirror, but is hidden from most of the incoming interference. Once line of sight access is eliminated, the scattering properties of the telescope support structure provide the only access for interfering signals. Research is being directed to ways of reducing this scattering and diffraction process. A solution to the complicated scattering problem is not easy to achieve but future technology may some day result in rendering the platform less susceptible to this phenomenon, thus "stealthing" the platform from incoming RF interference. The Observatory is also diligent in using the latest receiver technology to deal with interference, which does gain access to the feeds. Cryogenic filters and new mixing schemes with low susceptibility to intermodulation are in place or under development.

Technical steps such as these are part of the solution, and complement the regulatory efforts. Nevertheless, it is essential that the chance of inadvertant damage to the research capabilities of this unique instrument be eliminated. In the meantime, however, the Observatory must find ways to reduce or eliminate harmful interference to radio astronomy research being conducted there.

The Puerto Rico Communications Zone

In 1958, the Commission created a National Radio Quiet Zone in portions of Virginia, West Virginia and Maryland in order to afford RF interference protection to the facilities of the National Radio Astronomy Observatory at Green Bank, West Virginia, as well as the facilities of the Naval Research Laboratory at Sugar Grove, West Virginia.

Report and Order in Docket No. 11745, *Amendment of Parts 2, 3, 4, 5, 6, 7, 9, 10, 11, 16, 20, and 21 of the Commission's Rules and Regulations to give interference protection to frequencies utilized for Radio Astronomy*, 17 RR 1738 (1958). In that Report and Order, the Commission stated:

> "[I]t is accepted generally that radio interference levels that are tolerable for ordinary radio communications may be intolerable for radio astronomy observations. The Commission is of the opinion that it would be in the public interest to provide maximum practical protection from interference to radio astronomy measurements at Green Bank and Sugar Grove without unduly disrupting existing radio services.

Id. at 1739. The interests of broadcast stations located in the NRQZ were specifically considered and addressed in the Report and Order:

> The Commission recognizes the need for broadcast services within the proposed restricted zone and does not believe that the proposed procedure from applicants within the zone will hamper such services. However, the possibility of interference to radio astronomy observations must be considered in order to provide maximum protection necessary to operations at NRAO and NRRO.
> ....
> It must be pointed out that the rules being adopted, while for the purpose of establishing a system by which radio astronomy observations near Green Bank may be protected, are not intended to impede the development of radio services. Appropriate consideration of radio astronomy problems and of radio service problems will be necessary on the part of all parties concerned to the end that neither activity will be adversely affected.

Id. at 1741. Accordingly, the Commission adopted the requirement that applicants for FCC authority to construct and operate, or for major modification of, any fixed radio transmitter within specified geographical coordinates must notify the NRAO in writing of the technical aspects of the application, including the antenna coordinates, antenna height, antenna directionalization, frequency, and type of emission and power. Applicants are also required to indicate the date of such notification in the application. The NRAO is permitted 20 days within which to comment or object to the application which the Commission will then consider together with "all aspects of the problem and take whatever action is deemed appropriate." *E.g.*, ¶ 73.1030(a).

Fifteen years later, the Commission amended its rules to establish a coordination procedure in order to provide protection from harmful radiation from non-Government radio stations to the U.S. Department of Commerce's Table Mountain Radio Receiving

Zone near Boulder, Colorado. Report and Order in Docket No. 18180, *Amendments to Parts 21, 23, 25, 73, 74, 78, 87, 89, 91 and 93 of the Commission's Rules Relative to the Protection of Table Mountain, Boulder, Colo., From Radio Interference*, 38 FCC 2d 468, 26 RR 2d 131 (1972). Although the procedure differs slightly from the National Radio Quiet Zone coordination rule, the fact remains that the Commission chose to require communications sources to make a special effort to afford protection to the Table Mountain facilities.[1]

For the reasons which have been discussed above, Cornell believes that the public interest would be served by the establishment of a similar procedure to assist Arecibo Observatory in determining whether various applications filed in Puerto Rico might cause harmful interference to its radio astronomy telescope. Cornell is mindful of the need to provide communications services in Puerto Rico and that the instant petition is not being filed in order to impede such services. All that is sought is a rule which requires affected applicants to notify Arecibo Observatory, providing the Observatory with sufficient technical information to permit it to ascertain whether potentially harmful interference would be caused and to give the Observatory the opportunity to explore alternatives with these applicants which would, through power reduction, site relocation, directionalization and the like, eliminate or sufficiently reduce possible deleterious effects. In the event that a mutually acceptable alternative cannot be found, the Observatory would then be given an opportunity to present its objection to the Commission for its consideration. The benefits of new or increased communications service could then be weighed with those of protecting radio astronomy research and an appropriate resolution reached by the Commission and its staff.

The existing rules have worked well for the Table Mountain Receiving Zone in Boulder, Colorado and for the NRAO in Green Bank, West Virginia and with only two exceptions, there is no history of litigation between broadcast applicants and the Table

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[1] The Commission noted that "[t]he Table Mountain facility is used by the National Bureau of Standards, the Environmental Research Laboratories, and the Institute of Telecommunications Sciences (ITS). ITS provides the primary research and analysis work for the Department of Commerce in support of the Office of Telecommunications Policy as directed by Executive Order 11556. Table Mountain also serves as the major receiving site for Commerce propagation studies on behalf of the Department of Defense and many other Federal Agencies. Uses of the facility are highly diverse in nature and duration, ranging from participation in the Platteville vertical ionospheric modification program to studies of the effects of weather on propagation and wave distortion, model antenna measurements, and radio astronomy." *Id.* at 469 n. 1, 26 RR 2d at 132 n. 1.

Mountain and NRAO quiet zones. In *Russel Shaffer*, 17 FCC 2d 49 (1969), the Review Board denied an application for a new FM station because it would have caused serious interference to the Table Mountain facilities, whose research was termed "unique and nationally important." *Id.* at 63.The remaining applicant was granted conditioned upon its eliminating any harmful interference to Table Mountain. *Id.* at 69. With regard to the National Radio Quiet Zone, the Commission recently affirmed the efficacy of ¶ 73.1030(a) of the Commission's rules. *Achernar Broadcasting Company,* 6 FCC Rcd 5393 (1991), appeal docketed, *Achernar Broadcasting Company v. FCC,* No. 91-1516 (D.C. Cir. October 21, 1991) and *Lindsay Television, Inc. v. FCC,* No. 92-1149 (D.C. Cir. April 6, 1992). In that case, the Commission denied two competing applications for a new television station on Channel 64 in Charlottesville, Virginia because the both applicants would cause substantial interference to radio astronomy research being conducted at the Green Bank facility. Cornell submits that for the same reasons that the Commission found the public interest was served by creating zones surrounding NRAO's radio astronomy telescopes in Green Bank and on Table Mountain in Colorado, the public interest would be served by establishing a communications zone in Puerto Rico to protect the radio astronomy research facilities at the Arecibo Observatory.

The geographical considerations suggest that the simplest solution would be to constitute the entire island as a communications zone for purposes of notification under the rules proposed by Cornell. Regular monitoring of known and unknown incoming signals is being conducted in order to identify the sources of interference at the Observatory. Because of the range of observable frequencies used to conduct research, the Observatory has experienced interference from a number of different sources throughout all of Puerto Rico. Cornell accepts the fact that presently licensed communications facilities will continue to operate and will be unaffected by a communications zone rule established for the island; only new applications and modifications of existing operations will fall within the ambit of the new rule.

For the foregoing reasons, the Commission is requested to issue a Notice of Proposed Rulemaking proposing to amend Parts 5, 21, 22, 23, 25, 73, 74, 78, 80, 87, 90, 94, 95 and 97 of the Rules to establish a Radio Astronomy Communications Zone in Puerto Rico as set forth in Attachment A hereto.

Respectfully submitted,
CORNELL UNIVERSITY

By: 
Christopher J. Reynolds
Its Attorney

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November 25, 1992

Attachment A

1. Part 5 of Title 47 of the Code of Federal Regulations is amended as follows:

(i) Section 5.69, Notification to the National Radio Astronomy Observatory, is designated as Section 5.69(a).

(ii) Section 5.69(b), Notification to the Arecibo Observatory, is added to Part 5 to read as follows:

(b) **Notification to the Arecibo Observatory.** - In order to minimize possible harmful interference at the Arecibo Observatory site located near Arecibo, Puerto Rico, any applicant for a station authorization other than mobile, temporary base, temporary fixed, Personal Radio, Civil Air Patrol, or Amateur seeking a station license for a new station, a construction permit to construct a new station or to modify an existing station license in a manner which would change either the frequency, power, antenna height or directivity, or location of such a station on the islands of Puerto Rico, Desecheo, Mona, Vieques and Culebra shall, at the time of filing such application with the Commission, simultaneously notify the Interference Office, Arecibo Observatory, Post Office Box 995, Arecibo, Puerto Rico 00613, in writing, of the technical particulars of the proposed station. Such notification shall include the geographical coordinates of the antenna, antenna height above ground, antenna directivity (if any), proposed frequency, type of emission, and power. In addition, the applicant shall indicate in his application to the Commission the date notification was made to the Observatory. After receipt of such applications, the Commission will allow a period of twenty (20) days for comments or objections in response to the notifications indicated. If an objection to the proposed operation is received during the 20-day period from the Arecibo Observatory, the Commission will consider all aspects of the problem and take whatever action is deemed appropriate.

2. Part 21 of Title 47 of the Code of Federal Regulations is amended as follows:

Section 21.113(d), Notification to the Arecibo Observatory, is added to Part 21 to read as follows:

(d) **Notification to the Arecibo Observatory.** - In order to minimize possible harmful interference at the Arecibo Observatory site located near Arecibo, Puerto Rico, any applicant for a station authorization other than mobile, temporary base, or temporary fixed seeking authorization for a new station or to modify an existing station license in a manner which would change either the frequency, power, antenna height or directivity, or location of such a station on the islands of Puerto Rico, Desecheo, Mona, Vieques and Culebra shall, at the time of filing such application with the Commission, simultaneously notify the Interference Office, Arecibo Observatory, Post Office Box 995, Arecibo, Puerto Rico 00613, in writing, of the technical particulars of the proposed station. Such notification shall include the geographical coordinates of the antenna, antenna height above ground, antenna directivity (if any), proposed frequency, type of emission, and power. In addition, the applicant shall indicate in his application to the Commission the date notification was made to the Observatory. After receipt of such applications, the Commission will allow a period of twenty (20) days for comments or objections in response to the notifications indicated. If an objection to the proposed operation is received during the 20-day period

from the Arecibo Observatory, the Commission will consider all aspects of the problem and take whatever action is deemed appropriate.

3. Part 22 of Title 47 of the Code of Federal Regulations is amended as follows:

Section 22.113(d), Notification to the Arecibo Observatory, is added to Part 22 to read as follows:

(d) **Notification to the Arecibo Observatory**. - In order to minimize possible harmful interference at the Arecibo Observatory site located near Arecibo, Puerto Rico, any applicant for a station authorization other than mobile, temporary base, or temporary fixed seeking authorization for a new station or to modify an existing station license in a manner which would change either the frequency, power, antenna height or directivity, or location of such a station on the islands of Puerto Rico, Desecheo, Mona, Vieques and Culebra shall, at the time of filing such application with the Commission, simultaneously notify the Interference Office, Arecibo Observatory, Post Office Box 995, Arecibo, Puerto Rico 00613, in writing, of the technical particulars of the proposed station. Such notification shall include the geographical coordinates of the antenna, antenna height above ground, antenna directivity (if any), proposed frequency, type of emission, and power. In addition, the applicant shall indicate in his application to the Commission the date notification was made to the Observatory. After receipt of such applications, the Commission will allow a period of twenty (20) days for comments or objections in response to the notifications indicated. If an objection to the proposed operation is received during the 20-day period from the Arecibo Observatory, the Commission will consider all aspects of the problem and take whatever action is deemed appropriate.

4. Part 23 of Title 47 of the Code of Federal Regulations is amended as follows:

Section 23.20(f), Notification to the Arecibo Observatory, is added to Part 23 to read as follows:

(f) **Notification to the Arecibo Observatory**. - In order to minimize possible harmful interference at the Arecibo Observatory site located near Arecibo, Puerto Rico, any applicant for a station authorization other than mobile, temporary base, temporary fixed, Personal Radio, Civil Air Patrol, or Amateur seeking a station license for a new station, a construction permit to construct a new station or to modify an existing station license in a manner which would change either the frequency, power, antenna height or directivity, or location of such a station on the islands of Puerto Rico, Desecheo, Mona, Vieques and Culebra shall, at the time of filing such application with the Commission, simultaneously notify the Interference Office, Arecibo Observatory, Post Office Box 995, Arecibo, Puerto Rico 00613, in writing, of the technical particulars of the proposed station. Such notification shall include the geographical coordinates of the antenna, antenna height above ground, antenna directivity (if any), proposed frequency, type of emission, and power. In addition, the applicant shall indicate in his application to the Commission the date notification was made to the Observatory. After receipt of such applications, the Commission will allow a period of twenty (20) days for comments or objections in response to the notifications indicated. If an objection to the proposed operation is received

during the 20-day period from the Arecibo Observatory, the Commission will consider all aspects of the problem and take whatever action is deemed appropriate.

5. Part 25 of Title 47 of the Code of Federal Regulations is amended as follows:

Section 25.203(i), Notification to the Arecibo Observatory, is added to Part 25 to read as follows:

(i) **Notification to the Arecibo Observatory**. - In order to minimize possible harmful interference at the Arecibo Observatory site located near Arecibo, Puerto Rico, any applicant for a station authorization other than mobile, temporary base, temporary fixed, Personal Radio, Civil Air Patrol, or Amateur seeking a station license for a new station, a construction permit to construct a new station or to modify an existing station license in a manner which would change either the frequency, power, antenna height or directivity, or location of such a station on the islands of Puerto Rico, Desecheo, Mona, Vieques and Culebra shall, at the time of filing such application with the Commission, simultaneously notify the Interference Office, Arecibo Observatory, Post Office Box 995, Arecibo, Puerto Rico 00613, in writing, of the technical particulars of the proposed station. Such notification shall include the geographical coordinates of the antenna, antenna height above ground, antenna directivity (if any), proposed frequency, type of emission, and power. In addition, the applicant shall indicate in his application to the Commission the date notification was made to the Observatory. After receipt of such applications, the Commission will allow a period of twenty (20) days for comments or objections in response to the notifications indicated. If an objection to the proposed operation is received during the 20-day period from the Arecibo Observatory, the Commission will consider all aspects of the problem and take whatever action is deemed appropriate.

6. Part 73 of Title 47 of the Code of Federal Regulations is amended as follows:

(i) Section 73.1030(a), Radio astronomy and research installations, is designated as Section 73.1030(a)(1).

(ii) Section 73.1030(a)(2) is added to Part 73 to read as follows:

In order to minimize possible harmful interference at the Arecibo Observatory site located near Arecibo, Puerto Rico, a licensee proposing to operate a short-term broadcast auxiliary station pursuant to Section 74.24, or an applicant for authority to construct a new broadcast station or for authority to make changes in the frequency, power, antenna height or antenna directivity of an existing station on the islands of Puerto Rico, Desecheo, Mona, Vieques and Culebra shall, at the time of filing such application with the FCC, simultaneously notify the following:

Interference Office
Arecibo Observatory
Post Office Box 995
Arecibo, Puerto Rico 00613

The notification shall be in writing and set forth the particulars of the proposed station, including the geographical coordinates of the antenna, antenna height above ground, antenna directivity (if any), proposed frequency, type of emission, and power. In addition, the applicant shall indicate in his application to the FCC the date notification was made to the Observatory. After receipt of such applications, the FCC will allow a period of twenty (20) days for comments or objections in response to the notifications indicated. If an objection to the proposed operation is received during the 20-day period from the Arecibo Observatory, the FCC will consider all aspects of the problem and take whatever action is deemed appropriate.

7. Part 74 of Title 47 of the Code of Federal Regulations is amended as follows:

Section 74.24(i) is amended to read as follows:

Short-term operation of a remote control pickup broadcast station, a remote pickup automatic relay station, an aural broadcast STL station, an aural broadcast intercity relay station, a TV STL station, a TV intercity relay station or a TV translator relay station in the National Radio Quiet Zone, the Puerto Rico Communications Zone, the Table Mountain Radio Receiving Zone, or near FCC monitoring stations is subject to the same advance notification procedures applicable to regular applications as provided in Section 73.1030 and Section 74.12, except that inasmuch as short-term operation does not involve an application process, the provisions relating to agency objection procedures shall not apply. It shall simply be necessary for the Part 73 licensee to contact the potentially affected agency and obtain advance approval for the proposed short-term operation. Where protection to FCC monitoring station is concerned, approval for short-term operation may be given by the local Engineer-in-Charge.

8. Part 78 of Title 47 of the Code of Federal Regulations is amended as follows:

(i) The text following Section 78.19(c), Radio astronomy and Radio Research Installations, is designated subsection (1).

(ii) Section 78.19(c)(2) is added to Part 78 to read as follows:

In order to minimize possible harmful interference at the Arecibo Observatory site located near Arecibo, Puerto Rico, an applicant for authority to construct a cable television relay station, except a CARS pickup station, or for authority to make changes in the frequency, power, antenna height, or antenna directivity of an existing station on the islands of Puerto Rico, Desecheo, Mona, Vieques and Culebra shall, at the time of filing such application with the Commission, simultaneously notify the Interference Office, Arecibo Observatory, Post Office Box 995, Arecibo, Puerto Rico 00613, in writing, of the technical particulars of the proposed station. Such notification shall include the geographical coordinates of the antenna, antenna height above ground, antenna directivity (if any), proposed frequency, type of emission, and power. In addition, the applicant shall indicate in his application to the Commission the date notification was made to the Observatory. After receipt of such applications, the Commission will allow a period of twenty (20) days for comments or objections in response to the notifications indicated. If

an objection to the proposed operation is received during the 20-day period from the Arecibo Observatory, the Commission will consider all aspects of the problem and take whatever action is deemed appropriate.

9. Part 80 of Title 47 of the Code of Federal Regulations is amended as follows:

Section 80.21(f) is added to Part 80 to read as follows:
(f) In order to minimize possible harmful interference at the Arecibo Observatory site located near Arecibo, Puerto Rico, an applicant for a new station authorization (other than mobile or temporary fixed), or for modification of an existing license to change the frequency, power, antenna location, height or directivity on the islands of Puerto Rico, Desecheo, Mona, Vieques and Culebra must, at the time of filing such application with the Commission, notify the Interference Office, Arecibo Observatory, Post Office Box 995, Arecibo, Puerto Rico 00613, in writing, of the geographical coordinates of the antenna, antenna height above ground, antenna directivity (if any), proposed frequency, type of emission, and power. The application must show the date notification was made to the Observatory. The Commission will allow twenty (20) days after receipt of the notification for comments or objections. If a timely objection is received, the Commission will consider the comments or objections and act appropriately.

10. Part 87 of Title 47 of the Code of Federal Regulations is amended as follows:

(i) The text following Section 87.23(a), is designated subsection (1).

(ii) Section 87.23(a)(2) is added to Part 87 to read as follows:

(2) In order to minimize possible harmful interference at the Arecibo Observatory site located near Arecibo, Puerto Rico, an applicant for a new station license (other than mobile, temporary base, temporary fixed or Civil Air Patrol), or for modification of an existing license to change the frequency, power, antenna location, height or directivity on the islands of Puerto Rico, Desecheo, Mona, Vieques and Culebra must first notify the Interference Office, Arecibo Observatory, Post Office Box 995, Arecibo, Puerto Rico 00613, in writing, of the geographical coordinates of the antenna, antenna height above ground, antenna directivity, frequency, emission, and power. The application to the Commission must show the date notification was made to the Observatory. The Commission will allow twenty (20) days after receipt of its copy of the notification for comments or objections. If a timely response is received, the Commission will consider the comments or objections.

11. Part 90 of Title 47 of the Code of Federal Regulations is amended as follows:

(i) Section 90.129(e) is amended to read as follows:

(e) Applicants proposing to construct a radio station in the vicinity of radio astronomy observatories in West Virginia; the islands of Puerto Rico, Desecheo, Mona, Vieques and Culebra; or in the vicinity of a radio receiving zone in Colorado must submit the statements prescribed by Section 90.177.

(ii) Section 90.177, Protection of certain radio receiving locations, and subsections (a) and (b) are amended to read as follows:

90.177 **Protection of certain radio receiving locations.** - This section pertains to applications for new or modified authorizations in the vicinity of the National Radio Astronomy Observatory, Green Bank, Pocahontas County, W. Va.; the Naval Radio Research Observatory, Sugar Grove, Pendleton County, W. Va.; the Arecibo Observatory, Arecibo, Puerto Rico; the Table Mountain Radio Receiving Zone, Boulder County, Colo.; the Federal Communications Commission monitoring stations and other protected sites.

(a) Any applicant for a new permanent base or fixed station, or for a modification of an existing authorization which would change the frequency, power, antenna height, directivity, or location within the boundaries described in paragraph (b) of this section shall notify the Director, National Radio Astronomy Observatory, P.O. Box 2, Green Bank, W. Va. 24944 or Interference Office, Arecibo Observatory, Post Office Box 995, Arecibo, Puerto Rico 00613, respectively, in writing, of the technical parameters of the proposal.

(1) The notification shall be made prior to, or simultaneously with, the filing of the application with the Commission.

(2) The notification shall state the geographical coordinates of the antenna, antenna height above ground, antenna directivity, proposed frequency, type of emission, and effective radiated power.

(3) After receipt of such applications, the Commission will allow a period of 20 days for comments or objections in response to the notifications indicated. If an objection to the proposed operation is received during the 20-day period from the National Radio Astronomy Observatory for itself or on behalf of the Naval Radio Research Observatory, or from the Arecibo Observatory, the Commission will consider all aspects of the problem and take whatever action is deemed appropriate.

(4) The provisions of this paragraph do not apply to applications for mobile, temporary base, or temporary fixed stations.

(b)(1) The area of concern for the National Radio Astronomy Observatory or the Naval Radio Research Observatory is the area bounded by 39 degrees, 15 minutes N. on the north, 78 degrees, 30 minutes W. on the east, 37 degrees, 30 minutes N. on the South, and 80 degrees, 30 minutes W. on the East.

(b)(2) The area of concern for the Arecibo Observatory is the islands of Puerto Rico, Desecheo, Mona, Vieques and Culebra.

12. Part 95 of Title 47 of the Code of Federal Regulations is amended as follows:

(i) Section 95.42 is added to Part 95 to read as follows:

95.42 **Considerations in the Puerto Rico Communications Zone.** - (a) The FCC may impose additional restrictions on a land station in a proposed GMRS system,

or on one in a GMRS system proposed for modification, if the station is proposed for or located at a point within the Puerto Rico Communications Zone on the islands of Puerto Rico, Desecheo, Mona, Vieques or Culebra.

(b) When applying for a license to put a land station at a point in the Puerto Rico Communications Zone, or when applying to change certain details in a station already licensed for such a point, the applicant must send a notice to the Arecibo Observatory (see Section 95.79).

(c) Restrictions may be imposed if the Arecibo Observatory files an objection with the FCC within 20 days after the application is filed with the FCC.

(ii) Section 95.79, Additional information for stations in the National Radio Quiet Zone, and subsection (a) are amended to read as follows:

95.79 **Additional information for stations in the National Radio Quiet Zone or the Puerto Rico Communications Zone.** - An application for a license for a new or modified GMRS system having a land station at a point within the National Radio Quiet Zone or the Puerto Rico Communications Zone (see Sections 95.41 and 95.42) must:

(a)(1) Send a notice to:

Director , National Radio Astronomy Observatory
Post Office Box 2
Green Bank, West Virginia 24944; or

(a)(2) Send a notice to:

Interference Office
Arecibo Observatory
Post Office Box 995
Arecibo, Puerto Rico 00613

13. Part 97 of Title 47 of the Code of Federal Regulations is amended as follows:

(i) Section 97.3(a)(30) is amended to read as follows:

(30) Puerto Rico Communications Zone. The islands of Puerto Rico, Desecheo, Mona, Vieques and Culebra.

(ii) Subsections (30) to (44) of Section 97.3(a) are renumbered Subsections (31) to (45).

(iii) Section 97.203(e) is amended to read as follows:

(e) Before establishing an automatically controlled beacon in the National Radio Quiet Zone or in the Puerto Rico Communications Zone, or before changed the transmitting frequency, transmitter power, antenna height or directivity, the station licensee must give written notification thereof to the Interference Office, National Radio Astronomy Observatory, P.O. Box 2, Green Bank, WV 24944 or to the Interference Office, Arecibo Observatory, P.O. Box 995, Arecibo, PR 00613.

(1) The notification must include the geographical coordinates of the antenna, antenna ground elevation above mean sea level (AMSL), antenna center of radiation above ground level (AGL), antenna directivity, proposed frequency, type of emission, and transmitter power.

(2) If an objection to the proposed operation is received by the FCC from the National Radio Astronomy Observatory at Green Bank, Pocahontas County, WV, for itself or on behalf of the Naval Research Laboratory at Sugar Grove, Pendleton County, WV, or from the Arecibo Observatory, Arecibo, PR, within 20 days from the date of notification, the FCC will consider all aspects of the problem and take whatever action is deemed appropriate.

(iv) Section 97.205(f) is amended to read as follows:

(f) Before establishing a repeater in the National Radio Quiet Zone or in the Puerto Rico Communications Zone, or before changing the transmitting frequency, transmitter power, antenna height or directivity, or the location of an existing repeater, the station licensee must give written notification thereof to the Interference Office, National Radio Astronomy Observatory, P.O. Box 2, Green Bank, WV 24944 or to the Interference Office, Arecibo Observatory, P.O. Box 995, Arecibo, PR 00613.

(1) The notification must include the geographical coordinates of the station antenna, antenna ground elevation above mean sea level (AMSL), antenna center of radiation above ground level (AGL), antenna directivity, proposed frequency, type of emission, and transmitter power.

(2) If an objection to the proposed operation is received by the FCC from the National Radio Astronomy Observatory at Green Bank, Pocahontas County, WV, for itself or on behalf of the Naval Research Laboratory at Sugar Grove, Pendleton County, WV, or from the Arecibo Observatory, Arecibo, PR, within 20 days from the date of notification, the FCC will consider all aspects of the problem and take whatever action is deemed appropriate.

Attachment B

TECHNICAL STATEMENT CONCERNING THE RADIO FREQUENCY INTERFERENCE ENVIRONMENT AT THE ARECIBO OBSERVATORY IN PUERTO RICO

I. ARECIBO OBSERVATORY

The Arecibo Observatory, the world's largest radio/radar telescope, is part of the National Astronomy and Ionosphere Center ("NAIC"), a federally owned national research center operated by Cornell University under the terms of a cooperative agreement with the US National Science Foundation. It is located at latitude 18.346°, longitude 66.753°, about seventeen kilometers south of Arecibo, a city on the north coast of the island of Puerto Rico. The telescope was constructed in 1960 - 63 and has been extensively upgraded in 1972 - 74 for operation at shorter wavelengths. The replacement cost today is estimated at $100 million. A new initiative aimed at upgrading the telescope for higher sensitivity and lower system temperatures is presently underway. This Gregorian Upgrade project has been funded by the NSF and NASA for $22.8 million. The Observatory has a staff of 132 persons in Puerto Rico and 12 persons in Ithaca, NY. The annual operating budget, supplied by the NSF and supplemented for planetary radar research by NASA, is currently $7.5 million.

The reflector of the Arecibo Observatory is 1000 feet in diameter, 167 feet deep and covers an area of about twenty acres. The surface consists of 40,000 perforated aluminum panels supported by a network of steel cables strung across a natural sinkhole. The surface has been adjusted to an accuracy of less than 0.1 inch standard deviation over the whole twenty acre surface. The 600 ton receiver platform is suspended at 450 feet above the reflector surface with cables from three concrete towers. The platform consists of a supporting triangle, a movable bow-shaped azimuth arm with two suspended receiver (carriage) houses. One carriage house carries the 430 MHz line feed mostly used for ionospheric measurements. The second carriage house has six line feeds ranging in frequency from 1000 MHz to 2380 MHz used for spectral line radio astronomy and radar astronomy experiments. During the Gregorian Upgrade program currently in progress, a Gregorian subreflector system will replace the second carriage house and will operate from 300 MHz to 10 GHz. The subreflector system will be housed in an 83 ft diameter space frame. A scale model of the Gregorian subreflector system has been installed and has been used

successfully up to frequencies of 12.2 GHz.

The Arecibo Observatory is by far the largest aperture telescope in the world. With its powerful transmitters, sensitive receivers and sophisticated data acquisition and analysis equipment, the Observatory plays a leading role as a versatile research instrument in radiophysics. Basic research in radio astronomy, radar astronomy, and atmospheric science have put a heavy demand on the telescope resulting in a backlog of approved proposals of close to one year. The telescope operates 24 hours per day all year round.

Planetary studies make use of a 500 kW S-band transmitter which, with the reflector's forward gain of 72 dB, is the world's most powerful radar. Achievements in this field include detailed maps of Venus and imaging of a binary asteroid less than a mile across.

Atmospheric science research at the Observatory uses powerful pulsed radars at 47 and 430 MHz as well as the S-band radar. These studies involve stratospheric wind shear and clear air turbulence, transport of pollutants affecting the ozone layer, and energy transport between different atmospheric regions. Besides conducting radio observations, the aeronomy group at the Observatory has also built up a unique optical laboratory over the last few years. Laser measurements are used to measure scattering from particles in the lower regions of the atmosphere. Sensitive optical detectors are used to measure the extremely low levels of natural line emissions from the night sky. These airglow emissions are due to atomic and molecular constituents of the atmosphere.

Radio astronomy observations at Arecibo use frequencies ranging from 25 MHz for pulsar research to 12.2 GHz for molecular line studies. Extremely precise measurements of pulsars at Arecibo have shown the existence of planetary size objects around a pulsar and have proven the existence of gravitational radiation, confirming Einstein's predictions to an accuracy of two percent. No other observatory in the world can even detect these effects. Neutral hydrogen observations of galaxies from beyond the Milky Way have revealed unexpected clustering of matter on extremely large scales, far larger than can be easily explained by current cosmological models. For the (presently) most extreme example, Arecibo observations have revealed a 21 cm neutral hydrogen line in a distant galaxy redshifted to 69 cm (432 MHz) wavelengths. This signal was underway for more than three billion years before being detected at Arecibo. Studies of a variety of molecules in our Galaxy as well as distant galaxies utilize a wide variety of receiving systems; this is a research capability

which will be greatly enhanced with the Gregorian subreflector system.

The research at Arecibo requires the most sensitive receivers. The 21 cm (1420 MHz) system routinely detects radiation from galaxies with a flux density of 10^{-29} W/m^2/Hz; a single snowflake striking the ground releases far more energy than is collected in a year's worth of such observations. The facilities are so sensitive that one can detect the signal from a child's walkie-talkie at a million miles distance.

The extreme sensitivity of the Arecibo telescope carries a simple but far-reaching burden. The loss of research capabilities at Arecibo means a permanent loss for mankind, because no other telescope in the world can serve as a replacement.

II. THE RFI SITUATION AT ARECIBO OBSERVATORY

The interference environment at Arecibo Observatory has worsened dramatically during the last decade. As a result much observing time is lost due to radio frequency interference ("RFI") and certain observations may not be possible in the future if the RFI environment at the Observatory is not controlled. A number of reasons can be identified for the increase of RFI:

1. system temperatures at the Observatory decrease steadily due to the application of state-of-the-art technology in the various stages of the observing systems.

2. scientists are searching for increasingly weaker signals as the horizons of understanding of celestial phenomena are widened. The scientists are looking for more intricate details in order to test theories or make more finely tuned models of the phyiscal processes at work in the universe.

3. the number of broadcasting services in Puerto Rico has increased steadily during this period and presently Puerto Rico is the second densest broadcasting region in the US after the New York - New Jersey area.

4. besides the fundamental emissions for all legitimate services various harmonic emissions occur. Even at levels considered legal by the FCC, these out-of-band emissions can be very powerful for the observing systems at the Observatory. These out-of-band signals can be far removed from the fundamental frequency; for instance, observers have encountered the 13^{th} to 16^{th} harmonics of FM stations during their 1400 MHz neutral hydrogen observations.

5. the observing platform is elevated above the surrounding terrain. As a result, the area north of the central mountain range is visible for the Observatory. Because the various services select the highest points for their transmitting facilities, a large fraction of the island is observable from the Observatory.

The dense broadcasting region has not prevented the Arecibo Observatory from obtaining valuable scientific data because the telescope is only looking upward. The telescope can only look at a 40 degree cone around the zenith. The telescope cannot be pointed at the horizon like the more conventional telescopes of the National Radio Astronomy Observatory in Green Bank, W.V. Interfering signals do not enter the Arecibo system via the main beam or the near sidelobes but rather via the far sidelobes of the system. Notwithstanding the unusual construction of the telescope and the high population density in the area, the RFI potential for the Arecibo telescope is very similar to that of the telescopes in Greeen Bank, which can point at the horizon.

The interfering signal enters the observing system at Arecibo via the far sidelobes. For the present observing systems these far sidelobes are composed of the intrinsic side lobes (sideways vision) of the line feeds and a contribution due to scattering from the platform structure. Radiation from the horizon can be scattered downwards by the platform into the primary surface and reflected upwards again into the feeds. At present the far sidelobe levels are at about 80 dB below the forward gain of the telescope. The observing platform, which is very exposed to all radiation from the horizon, renders the Observatory rather vulnerable for RFI. The Gregorian Upgrade for the Observatory is likely to alleviate the situation, because all higher frequency line feeds will be replaced with a single subreflector system placed in an 83 ft enclosed space frame. This will improve the far sidelobes of the feed system but does not eliminate the contribution of scattering from the platform. The Observatory can contribute to RFI suppression by reducing the scattering cross section of the platform to interfering radiation. However, the Observatory cannot reduce the incoming RFI signals. This must be a combined effort of the communication services and the FCC.

2.1 THE NEUTRAL HYDROGEN BAND

The neutral hydrogen band is of great importance for the Radio Astronomy Service ("RAS"). This band is being used most frequently by the Radio Astronomy Service for observation of neutral hydrogen in our Galaxy and other nearby galaxies.

Although astronomers will conduct passive experiments below this band to look at more distant objects, the RAS has Primary status in the frequency band only from 1400 to 1427 MHz.

The diagram in Figure 1 displays the RFI situation for neutral hydrogen observations. This diagram represents the cummulative occurence of RFI during actual observations in the month of May, 1992. The x-axis ranges from 1300 to 1430 MHz. Of this range only the 1400-1427 MHz region is protected. The y-axis of this diagram gives the percentage of time there was RFI in the data of the observers. The upper frame represents the distribution of actual observing time across the band. It is evident that RFI occurs at the whole frequency range. Some of these signals are from legitimate services like the San Juan airport radar (at 1330 and 1350 MHz) and the GPS satellites (at 1380 MHz). However, other signals have not been identified and some signals could be due to (13^{th} - 16^{th}) harmonics of FM stations or other out-of-band emissions.

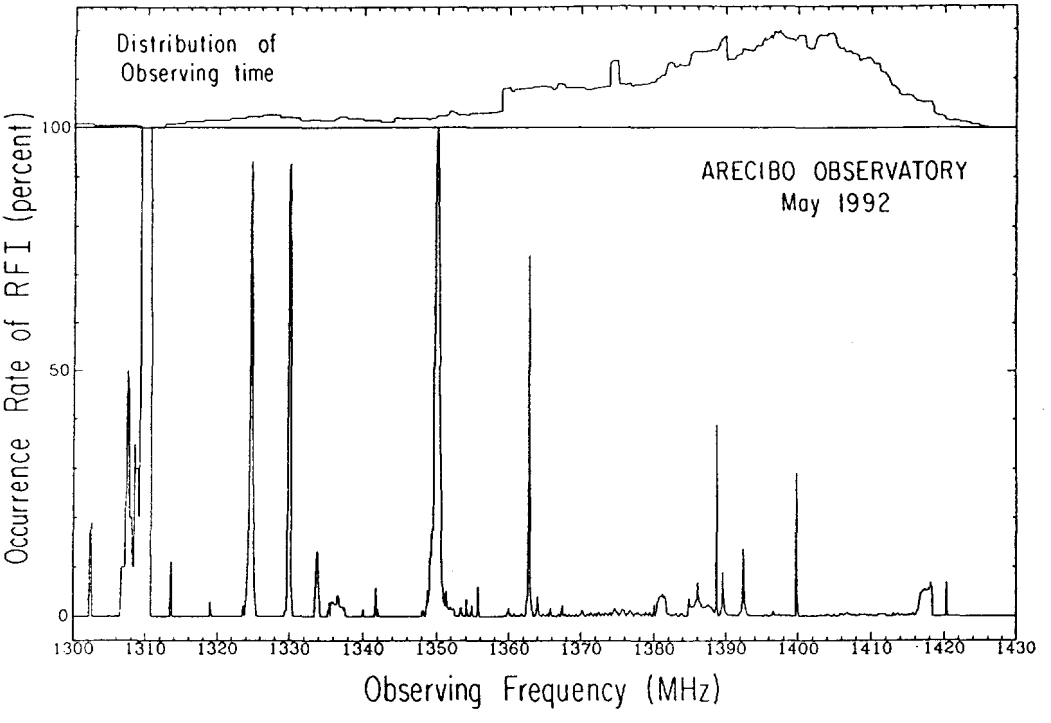

Figure 1. The Occurence of Interference with Frequency in the intensely used Frequency Range from 1300 to 1430 MHz. Frame a) displays the distribution of observing time at 20 cm (in hours) during the month of May 1992. Frame b) displays the fraction of time lost due to interference as a function of frequency.

2.2. EXAMPLES OF CONFLICTS

2.2.1 WNIK-FM has long been serving the Arecibo community from its downtown location. During the license renewal period in 1989 another organization submitted a competing application for the license of WNIK. This second organization proposed to move the transmitting facility away from the town of Arecibo in order to obtain a uniform coverage of the target area and to serve a larger audience. The Commission has encouraged such moves in the past. However, such a move would have severely effected the operation of the Arecibo Observatory. The existing transmitting facility was relatively low power and was relatively well shielded at its downtown location at a distance of 9.3 mi north of the Observatory. The new proposed facility would be at 3.9 mi south-west of the Observatory, would have a higher transmitting power and would be in plain view of the Observatory. The location would also have been inside the four mile Protection Zone established around the Observatory by the Commonwealth of Puerto Rico. The Observatory strongly objected to this proposed new broadcast station.

After closing of the application period, the FCC rejected the competing application and awarded the license renewal to the previous holders of the license on the basis of financial arguments. The FCC Review Board later upheld the decision. The arguments of Arecibo Observatory were not heard during the various proceedings but the interests of the Observatory have been served by these decisions. This case clearly brings out the vulnerability of the Arecibo Observatory and the need for increased protection of the Observatory within the rules of the Commission.

2.2.2 WCCV-TV from Camuy, PR, carries the license for Channel 54 allocated to Arecibo, PR. The transmission facilities of WCCV were located in downtown Arecibo. Channel 54 had earlier caused concern among the Arecibo Observatory staff because the second harmonics of its fundamental frequencies fall within the neutral hydrogen band of 1400 - 1427 MHz, where the RAS has primary status. With the rest frequency of neutral hydrogen at 1420.4058 MHz, this is the most widely observed astronomical frequency. In earlier years the Arecibo staff had already worked together with the WCCV-TV staff to install harmonic filters to suppress the transmitted power of the second harmonic.

During 1991 the Arecibo staff became aware of the fact that a new transmission facility was being built on a mountain south of the Observatory (BPCT-890609KF). It was discovered that WCCV-TV had been granted a construction permit to move

from its downtown location (10 miles north of the Observatory) to a location 7 miles south of the Observatory. Furthermore, the new facilities of WCCV-TV would have direct line-of-sight to the Observatory and would increase power from 56 kW to 1.5 MW. The Observatory staff had not learned earlier about the detailed plans for the proposed facilities. The WCCV-TV application for "minor modification" to its facilities had been processed in 1989. The Observatory staff had naively assumed that the Commission would protect the Observatory in such situations, and began monitoring applications to the FCC only in May, 1991.

In January 1992, the Cornell University filed a Petition for Extraordinary Relief before the Commission on behalf of the Arecibo Observatory. This pleading suggested technical solutions for the potential interference problems and only as a last resort asked for a Denial of License for WCCV-TV. In its reply to the Cornell Petition, WCCV-TV stated that it desires to cooperate with Cornell to resolve the situation and both parties have indeed been working together in good manner. The proposed technical solution involves (1) the installation of a waveguide switch and a dummy load to take the signal off the air totally at night, (2) the installation of harmonic and intermodulation filters, (3) the modification of the antenna patterns in order to reduce the power in the direction of the Observatory to a level similar to that of the station before its move, and (4) consultations with the Observatory staff about the placement of other services on the broadcasting tower.

Cornell and the Observatory are confident that a technical solution can be implemented at WCCV-TV and that the threat of harmonic and intermod interference for the AO observing systems can be alleviated. However, the situation with WCCV-TV again exposes the vulnerability of the Observatory and exemplifies the need for protection for this unique installation.

III. THE FUTURE OF THE OBSERVATORY

The susceptibility of the Observatory to RFI due to a large variety of services has made the AO staff increasingly aware of RFI problems and in a constant search for solutions. License applications at the Commission are presently being monitored for the AM/FM/TV broadcasting services and some action has already resulted from this monitoring. However, the frequencies used in passive experiments at AO ranges from 25 MHz to 12 GHz, and covers a large number of services. Monitoring and coordination are thus required over a much larger field than only the public